

evaluated and translated into technology requirements for researchers and engineers.

Here I first present the ethical and urgent matters which neuro-engineers identified as important regarding brain-computer interfacing (Nijboer et al., 2011). I also present the opinions of persons with neurodegenerative diseases (spinal muscular atrophy, amyotrophic lateral sclerosis) and persons with spinal cord injury. In comparison, it becomes clear that these stakeholders could greatly benefit from each other's knowledge. Thus, it is strongly recommended that potential users are involved in research and development of BCIs.

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## Brain-computer interfaces and virtual reality

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**Keywords:** Virtual Reality; Brain-Computer Interfaces; Serious Games; EEG; Neurofeedback; OpenViBE

Brain-Computer Interfaces (BCI) and Virtual Reality (VR) share the same strong evocative power. The connection between VR and BCI has already been established in two ways. First, Virtual Reality was shown to improve performance of BCI users by engaging the user in a more motivating scenario. In the other way, BCI were shown to enable control of virtual environments in various explicit or implicit manners.

In this talk we will illustrate state-of-the-art results obtained in the field of BCI and VR, such as in the frame of the OpenViBE2 ANR project which was dedicated to the use of BCI in videogames. We will notably present a serious game developed for children suffering from ADHD, which relies on EEG-based neurofeedback and on the immersion of the user in a virtual classroom in virtual reality.

The Speaker, Anatole Lécuyer, is Director of Research, and head of the Hybrid research team at the French National Institute for Research in Computer Science and Control (Inria), Rennes, France. His research interests include 3D user interfaces, force-feedback technology, and brain-computer interfaces. He has been the project leader of the renowned OpenViBE software for BCI and VR since 2005 (<http://openvibe.inria.fr>), and coordinator of ANR OpenViBE2 project on BCI and videogames (2009-2013).

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## Brain-Computer Interface research at the Graz University of Technology: Novel concepts in neurorehabilitation

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**Keywords:** Brain-Computer Interface; Electroencephalogram; Functional Brain Mapping

Brain-Computer Interfaces (BCIs) are devices that bypass the normal neuromuscular output pathways and translate a user's brain signal directly into action. Hence, BCIs have to monitor and interpret brain signals in real-time. Here, we review some recent work in the field of non-invasive electroencephalogram-based (EEG) BCI-assisted neurorehabilitation conducted at the Graz University of Technology. The review is divided into three parts. Firstly, we review our latest developments on BCI-based communication and control, and present our "plug and play" BCI [1]. The system autonomously adapts its parameters to fit the user's brain activity pattern – induced by performing mental tasks – during run-time, allowing basic communication after short periods of time. Secondly, we outline how BCI technology can be helpful for assessing active participation of individuals during gait rehabilitation [2,4]. Active participation is essential for successful rehabilitation. Thirdly, we present our first prototype of game-based functional motor mapping [3]. Our aim is to develop systems that allow measuring motor and brain activity while

individuals are engaged in rehabilitation and perform functionally meaningful tasks. Our results demonstrate both the feasibility and possible utility of incorporating BCI technology into clinical practice.

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## Brain computer interfaces: Principles and technological limits in rehabilitation

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**Keywords:** BCI; Communication; Assistive technology

The brain computer interfaces are devices for capturing and decoding brain signal to control robotic or computer supply systems. In very severe disabled persons, such interface can appear as the lonely possibility of supply.

Two main types of interface are described.

Non-invasive interfaces do not require any surgical implantation. They use the EEG signals. Synchronous interfaces using the properties of evoked potentials have been described. It is simple and robust interface, but with slow recording rate. More recently, asynchronous interfaces have been also described. These interfaces use the somatotopy variations of the EEG frequency during movement imagination. These interfaces require signal averaging and thus task repetitions. Non-invasive interfaces need long learning and involve major cognitive engagement. These interfaces are increasingly used in detecting states of consciousness and as temporary approach to communication in severe motor disability.

Invasive interfaces require the implantation of intracranial electrodes. They are based on the selective recording of fields or intra neuronal potentials. The record of a hundred neurons simultaneously allows to decode the direction of upper limb movement. These interfaces could have a high recording rate and are compatible with dual cognitive tasks. The implantation of electrodes limits interferences and improves the signal to noise ratio. It is a surgical procedure that is not without risk, but that is already widely and successfully used in the treatment of Parkinson's disease. In fact, the long-term biocompatibility of electrodes is in our opinion the main technological barrier of invasive interfaces. The Brain Machine interfaces should reach technological maturity in few years to come and take an increasing role in supply of severe disability.

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## How does BCI integrate our current strategies for rehabilitation after brain injury?

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